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(54) Hydrocarbon base cementitious drilling fluid

(57) A drilling fluid comprises a hydrocarbon liquid with particulate hydraulic cement suspended therein. After drilling, the drilling fluid can be converted to a cementitious composition by admixing water and a surfactant therewith, and can then set to a hard substantially impermeable mass.

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Description

The present invention relates generally to a hydrocarbon base drilling fluid and its use.

A variety of drilling fluids are used in drilling well bores by the rotary drilling method. The most commonly utilized such drilling fluids are solids containing water base gels. However, when the well bores to be drilled penetrate water sensitive formations, hydrocarbon base drilling fluids are utilized.

After a well bore has been drilled, with drilling fluid circulated through the well bore, the circulation of the drilling fluid is stopped and the well is usually logged after which a string of pipe, e.g. casing, is run into the well bore. The drilling fluid is cleaned up by circulating it downwardly through the interior of the pipe and upwardly through the annulus between the exterior of the pipe and the walls of the well bore while removing drilling solids and gas therefrom. Primary cementing operations are then performed in the well bore, i.e. the string of pipe disposed in the well bore is cemented therein by placing a cementing composition in the annulus between the pipe and the walls of the well bore. The cementing composition sets into a hard substantially impermeable mass whereby the pipe is bonded to the walls of the well bore and the annulus is sealed. When the cementing composition is run down the pipe and into the annulus, the drilling fluid in the pipe and annulus is displaced therefrom. The used drilling fluid is generally accumulated in a pit or tank and then disposed of.

The disposal of drilling fluid is time consuming and expensive, particularly in offshore drilling locations. In recent years, the expense has increased significantly in that drilling fluid often must be disposed of as a fluid which is hazardous to the environment. Thus, any environmentally safe use to which all or part of the drilling fluid can be put at a well site is highly advantageous in that it eliminates the need for subsequently disposing of all or part of the drilling fluid.

We have now devised a hydrocarbon base drilling fluid which can be more readily disposed of after use and can be put to another use within the well.

The present invention provides a hydrocarbon base drilling fluid which is selectively convertible to a cementitious composition that sets into a hard substantially impermeable mass by admixing water and a surfactant therewith, said drilling fluid comprising a hydrocarbon liquid; and particulate hydraulic cement suspended in said hydrocarbon liquid in an amount of from 1 to 4.3 parts by weight of cement per 1 part by weight of hydrocarbon liquid. The present invention also provides a method of drilling a well bore utilizing a hydrocarbon base cementitious drilling fluid of this invention which method comprises the steps of:

(a) drilling the well bore using a hydrocarbon base drilling fluid of the invention;

(b) converting the drilling fluid into a cementitious composition which sets into a hard substantially impermeable mass by admixing therewith water and a surfactant for promoting contact between said water and the hydraulic cement; and

(c) placing the cementitious composition in one or more desired locations whereby it sets into hard environmentally safe cementitious masses therein.

In the hydrocarbon base cementitious drilling fluids of this invention, the hydrocarbon liquid is preferably a relatively low viscosity, non-volatile liquid.

A variety of relatively low viscosity and non-volatile hydrocarbon liquids can be utilized. For example, the hydrocarbon liquid can be an aliphatic compound such as hexane, heptane or octane, an aromatic compound such as benzene, toluene or xylene, mixtures of aliphatic and aromatic compounds such as kerosene, diesel oil, mineral oil and lubricating oil, poly -olefin oils and ester and ether based oils. Generally, a hydrocarbon liquid selected from kerosene, diesel oil, mineral oil and lubricating oil is preferred, with diesel oil being the most preferred.

Various hydraulic cementitious materials can be utilized in the drilling fluids such as Portland cement, high alumina cement, Portland cement and slag, slag activated with a suitable alkali activator, e.g. soda ash and/or caustic, fly ash of the ASTM Class F type with lime, fly ash of the ASTM Class C type, condensed silica fume with lime, gypsum cement (calcium sulfate hemihydrate) and mixtures of such cementitious materials. Of these, Portland cement and mixtures of Portland cement and slag are preferred with Portland cement being the most preferred.

While particulate hydraulic cements having various particle sizes can be utilized in accordance with this invention, fine particle size Portland cement is generally preferred, e.g., Portland cement having particles of diameters no greater than about 30 microns and having a Blaine Fineness no less than about 6000 scuare centimeters per gram. Fine particle size Portland cement is disclosed in U.S. Patent No. 4,160,674 issued on July 10, 1979 to Sawyer. Methods of utilizing such fine particle size Portland cement in well cementing are described in U.S. Patent No. 5,086,850 entitled "Squeeze Cementing" issued on July 16, 1992 and U.S. Patent No. 5,125,455 entitled "Primary Cementing" issued on June 30, 1992, which patents are incorporated herein by reference thereto.

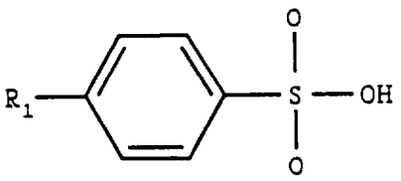
The fine particle size Portland cement used in accordance with this invention is preferably made up of particles having diameters no larger than about 30 microns, more preferably no larger than about 17 microns and still more preferably no larger than about 11 microns. The distribution of various sized particles within the cementitious materials is preferably such that 90% of the particles have a diameter no greater than about 25 microns, more preferably about 10 microns and still more preferably about 7 microns, 50% of the particles have a diameter no greater than about 10 microns, more preferably

about 6 microns and still more preferably about 4 microns, and 20% of the particles have a diameter no greater than about 5 microns, more preferably about 3 microns and still more preferably about 2 microns. The Elaine Fineness of the particles is preferably no less than about 6000 scuare centimeters per gram. More preferably, the Elaine Fineness is no less than about 7000, still more preferably about 10,000 and most preferably no less than about 13,000 scuare centimeters per gram.

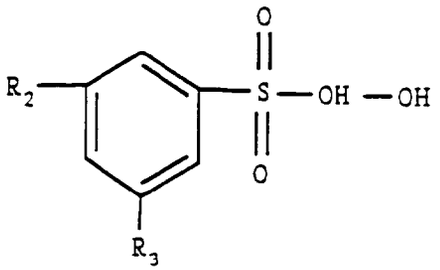
As will be understood by those skilled in the art, the drilling fluids of this invention can optionally contain various known additives in admixture therewith including fluid loss control additives, viscosifiers, dispersants, surfactants and weighting materials. Appropriate additives are utilized to provide a drilling fluid with the required properties for the particular well bore to be drilled including fluid loss control properties, density, solid suspension properties, etc. The hydrocarbon base drilling fluids of this invention can have densities up to about 15 pounds per gallon and yield points in the range of from about 5 to about 80 foot-pounds per 100 square feet.

The hydrocarbon base drilling fluids of this invention can be selectively converted to cementitious compositions which set into hard substantially impermeable masses by admixing therewith water and a surfactant which promotes contact between the water and the particulate hydraulic cement in the drilling fluid. Prior to being converted to a cementitious composition, the particulate hydraulic cement in the drilling fluid is coated with hydrocarbon liquid, and as a result, the drilling fluid can tolerate the low levels of water contamination experienced during drilling. When converted, the surfactant admixed with the drilling fluid along with water strips the hydrocarbon coating from the cement particles which allows the cement particles to chemically react with the water and undergo hydration. As will be understood, additional additives can be added to the drilling fluid when it is converted to impart desired properties to the resulting cementitious composition. Examples of such additives are set delaying additives, additives to prevent compressive strength retrogression and the like.

Particularly suitable surface active agents for use in accordance with this invention are aromatic sulfonic acids and salts. Preferably, the surface active agent is selected from the group consisting of an aromatic sulfonic acid having the formula



wherein R_1 is a linear alkyl group having 12 carbon atoms or a linear alkyl group having from 16 to 24 carbon atoms, an aromatic sulfonic acid having the formula



wherein R_2 and R_3 are linear alkyl groups having 12 carbon atoms, and the alkali and alkaline earth metal salts of the foregoing acids. The most preferred surface active agents of the type described above for use in accordance with this invention are one or more selected from the group consisting of dodecylbenzene sulfonic acid and the alkali metal salts thereof.

As mentioned above, when it is desired to convert a hydrocarbon base drilling fluid of this invention to a cementitious composition which sets into a hard substantially impermeable mass, water and a surfactant of the type described above is admixed with the drilling fluid. Generally, the water is admixed with drilling fluid in an amount in the range of from about 20% to about 175% by weight of particulate hydraulic cement in the drilling fluid. The surface active agent used is admixed with the drilling fluid in an amount in the range of from about 0.015 gallon to about 0.03 gallon of surfactant per gallon of hydrocarbon liquid in the drilling fluid.

For ease of mixing, the surface active agent can be dissolved in a low molecular weight alcohol such as an aliphatic alcohol having in the range of from 1 to about 5 carbon atoms. Isopropanol is a particularly preferred such alcohol, and the aromatic sulfonic acid or sulfonate utilized is preferably dissolved in the alcohol in an amount in the range of from about 60 to about 80 parts per 100 parts by volume of solution.

The methods of this invention for drilling a well bore utilizing a hydrocarbon base drilling fluid and subsequently disposing of the drilling fluid are basically comprised of the following steps. A hydrocarbon base drilling fluid comprised of a relatively low viscosity and non-volatile hydrocarbon liquid having particulate hydraulic cement suspended therein is formed. The hydraulic cement is included in the drilling fluid in an amount in the range of from about 1 part by weight to about 4.3 parts by weight of cement per 1 part by weight of hydrocarbon liquid.

After forming the drilling fluid, it is utilized in the usual manner for drilling a well bore. Upon completion of the well bore, the drilling fluid is converted into a cementitious composition which sets into a hard substantially impermeable mass by admixing therewith water and a surfactant of the type described above for promoting contact between the water and the hydraulic cement in the drilling fluid. The resulting cementitious composition is disposed of by placing it in one or more desired locations whereby it sets into a hard environmentally safe cemen-

titious mass or masses therein.

One of the above mentioned locations can be a location in the well bore. That is, a part of the converted cementitious drilling fluid can be utilized for carrying out well bore cementing operations such as primary cementing. The remaining drilling fluid, or all of the drilling fluid if a portion of it is not used for primary cementing or other cementing at the well site can be transported to a location remote from the well site, converted to a cementitious composition, and placed in an above-ground or below-ground location whereby it sets into a hard environmentally safe cementitious mass therein.

When the drilling fluid is converted, the mixing of the water and surface active agent with all or a portion of the drilling fluid can be accomplished by installing an in-line mixing device in the drilling fluid line downstream of the drilling rig solids removal equipment and upstream of the Kelly hose. As the drilling fluid is circulated through the line, the in-line mixing device is utilized for injecting the required volumes of water and surface active agent into the drilling fluid. The turbulence imparted by the in-line mixer causes the water and surface active agent to be blended with the drilling fluid and enables the surface active agent to strip the hydrocarbon liquid coating from the cement particles, etc. Alternatively, a pump truck having pumps and a mixer mounted thereon can be utilized for admixing the water and surface active agent with the drilling fluid as the drilling fluid is being circulated.

Claims

1. A hydrocarbon base drilling fluid which is selectively convertible to a cementitious composition that sets into a hard substantially impermeable mass by admixing water and a surfactant therewith, said drilling fluid comprising a hydrocarbon liquid; and particulate hydraulic cement suspended in said hydrocarbon liquid in an amount of from 1 to 4.3 parts by weight of cement per 1 part by weight of hydrocarbon liquid.

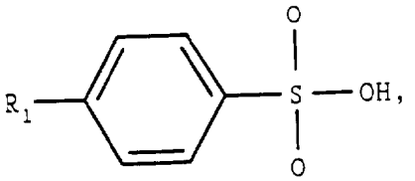
2. A drilling fluid according to claim 1, wherein the hydrocarbon liquid is kerosene, diesel oil, mineral oil, lubricating oil, poly -olefin oil or ester or ether based oils.

3. A drilling fluid according to claim 1 or 2, wherein the hydraulic cement is fine particle size cement.

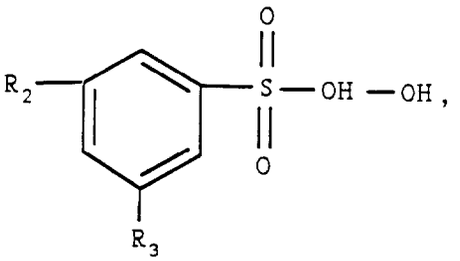
4. A drilling fluid according to claim 1, 2 or 3, wherein the cement is a fine particle size portland cement having a particle size no greater than 30 microns and a Blaine fineness no less than 6000 square centimetres per gram.

5. A cementitious composition which comprises a drilling fluid as claimed in claim 1, 2, 3 or 4, a surfactant and water in an amount of from 20% to 175% by weight of the hydraulic cement in said drilling fluid.

6. A composition according to claim 5, wherein the surfactant is an aromatic sulfonic acid having the formula



an aromatic sulfonic acid having the formula



or an alkali or alkaline earth metal salts of one of the foregoing acids, wherein R_1 is a linear alkyl group having 12 carbon atoms or a linear alkyl group having from 16 to 24 carbon atoms, and R_2 and R_3 are linear alkyl groups having 12 carbon atoms.

7. A composition according to claim 6, wherein the surfactant is dodecylbenzene sulfonic acid or an alkali metal salt thereof.

8. A composition according to claim 5, 6 or 7, wherein the surfactant is mixed with the drilling fluid in an amount of from 0.015 to 0.03 volumes of surfactant per volume of hydrocarbon liquid in said drilling fluid.

9. A composition according to claim 5, 6, 7 or 8, wherein the surfactant is mixed with the drilling fluid in the form of an alcohol solution containing said surfactant, said alcohol being an aliphatic alcohol having from 1 to 5 carbon atoms.

10. A method of drilling a well bore utilizing a hydrocarbon base drilling fluid and subsequently disposing of the drilling fluid which method comprises the steps of:

(a) drilling the well bore using a hydrocarbon base drilling fluid as claimed in any of claims 1 to 4;
(b) converting the drilling fluid into a cementitious composition which sets into a hard substantially impermeable mass by admixing therewith water and a surfactant for promoting contact between said water and the hydraulic

cement; and
(c) placing the cementitious composition in one or more desired locations whereby it sets into hard environmentally safe cementitious masses therein.

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EUROPEAN SEARCH REPORT

Application Number
EP 95 30 7241

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	US-A-5 213 160 (J.J.W.NAHM) * column 2, line 14 - line 61 * * column 3, line 1 - line 34 * * column 4, line 3 - line 68 * * column 6, line 17 - line 27 *	1-3,6,10	C09K7/06 E21B33/13
Y	US-A-5 314 022 (K.M.COWAN) * column 2, line 48 - column 3, line 10 * * column 3, line 42 - column 4, line 19 * * column 5, line 6 - line 33 * * column 12, line 7 - line 19 *	1-3,6,10	
Y	US-A-3 065 172 (W.L.GROVES JUNIOR) * column 2, line 26 - column 3, line 51 *	1-3,6,7	
Y	US-A-3 099 624 (D.L.WILSON) * column 2, line 14 - line 69 * * column 3, line 34 - line 52 *	1,2,6,7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6) C09K E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 January 1996	Boulon, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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